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NATIONAL DAM SAFETY PROGRAM. CITY LAKE DAM (MO 20314), MISSOURI--ETC(U)
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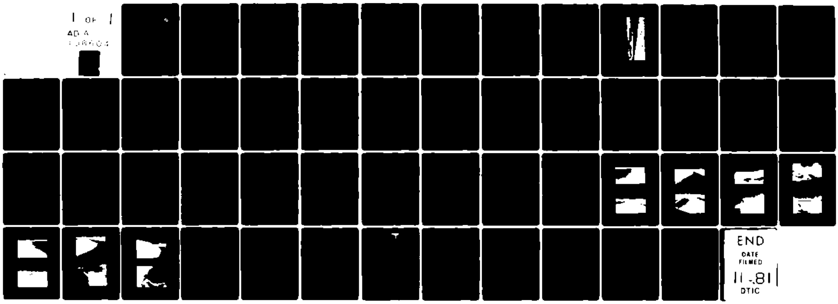

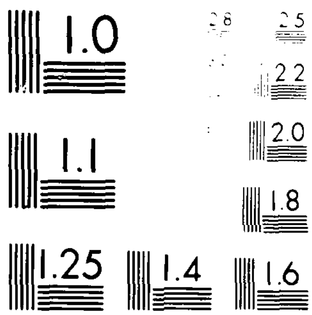
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MISSOURI-KANSAS CITY BASIN

AD A108604

CITY LAKE DAM

CASS COUNTY, MISSOURI

MO 20314

PHASE 1 INSPECTION REPORT NATIONAL DAM SAFETY INSPECTION

United States Army Corps of Engineers
...Serving the Army
...Serving the Nation

St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1979

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SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

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1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A106 604
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4. TITLE (and Subtitle) Phase I Dam Inspection Report National Dam Safety Program City Lake Dam (MO 20314) Cass County, Missouri	5. TYPE OF REPORT & PERIOD COVERED 9 Final Report
	6. PERFORMING ORG. REPORT NUMBER
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18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Dam Safety, Lake, Dam Inspection, Private Dams

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report was prepared under the National Program of Inspection of Non-Federal Dams. This report assesses the general condition of the dam with respect to safety, based on available data and on visual inspection, to determine if the dam poses hazards to human life or property.

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MISSOURI-KANSAS CITY BASIN

CITY LAKE DAM

CASS COUNTY, MISSOURI

MO 20314

PHASE 1 INSPECTION REPORT
NATIONAL DAM SAFETY INSPECTION

United States Army
Corps of Engineers
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St. Louis District

PREPARED BY: U.S. ARMY ENGINEER DISTRICT, ST. LOUIS

FOR: STATE OF MISSOURI

APRIL 1979

DEPARTMENT OF THE ARMY
ST. LOUIS DISTRICT, CORPS OF ENGINEERS
210 NORTH 12TH STREET
ST. LOUIS, MISSOURI 63101

IN REPLY REFER TO

SUBJECT: City Lake Dam Phase I Inspection Report

This report presents the results of field inspection and evaluation of the City Lake Dam:

It was prepared under the National Program of Inspection of Non-Federal Dams.

This dam has been classified as unsafe, non-emergency by the St. Louis District as a result of the application of the following criteria:

1) Spillway will not pass 50 percent of the Probable Maximum Flood
2) Overtopping could result in dam failure
3) Dam failure significantly increases the hazard to loss of life downstream

SUBMITTED BY: SIGNED — Chief, Engineering Division — 30 JUL 1979 — Date

APPROVED BY: SIGNED — Colonel, CE, District Engineer — 30 JUL 1979 — Date

CITY LAKE DAM

CASS COUNTY, MISSOURI

MISSOURI INVENTORY NO. 20314

PHASE I INSPECTION REPORT

NATIONAL DAM SAFETY PROGRAM

PREPARED BY:

BLACK & VEATCH
CONSULTING ENGINEERS
KANSAS CITY, MISSOURI

UNDER DIRECTION OF

ST. LOUIS DISTRICT CORPS OF ENGINEERS

FOR

GOVERNOR OF MISSOURI

APRIL 1979

PHASE I REPORT

NATIONAL DAM SAFETY PROGRAM

Name of Dam	City Lake Dam
State Located	Missouri
County Located	Cass County
Stream	Town Creek
Date of Inspection	12 April 1979

City Lake Dam was inspected by a team of engineers from Black & Veatch, Consulting Engineers for the St. Louis District, Corps of Engineers. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

The guidelines used in the assessment were furnished by the Department of the Army, Office of the Chief of Engineers and developed with the help of several Federal and state agencies, professional engineering organizations, and private engineers. Based on these guidelines, this dam is classified as a small size dam with a high downstream hazard potential. According to the St. Louis District, Corps of Engineers failure would threaten the life and property of approximately 12 families, damage two buildings downstream of the dam and would potentially cause appreciable damage to U.S. Highway 71 and the St. Louis/San Francisco and the Missouri Pacific railroads within the estimated damage zone which extends approximately two miles downstream of the dam. The failure of this dam may cause the Luna Lake Dam downstream to fail which then would cause the damage mentioned above.

Our inspection and evaluation indicates the spillway does not meet the criteria set forth in the guidelines for a dam having the above size and hazard potential. The spillway will not pass the probable maximum flood or 50 percent of the probable maximum flood without overtopping but will pass 40 percent of the probable maximum flood, which is greater than the 100-year flood. The spillway design flood recommended by the guidelines is 50 to 100 percent of the probable maximum flood. Considering the small volume impounded and the downstream hazard, 50 percent of the probable maximum flood is the appropriate spillway design flood. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region.

Deficiencies visually observed by the inspection team were erosion, absence of the riprap, protection on the upstream slope, sloughing of

the upstream embankment, and erosion of the downstream embankment slope. Seepage and stability analyses required by the guidelines were not available.

There were no observed deficiencies or conditions existing at the time of the inspection which indicated an immediate safety hazard. Future corrective action and regular maintenance will be required to correct or control the described deficiencies. In addition, detailed seepage and stability analyses of the existing dam, as required by the guidelines, should be performed. A detailed report discussing each of these deficiencies is attached.

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Edwin R Burton

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Harry L Callahan

Harry L. Callahan, Partner
Black & Veatch

OVERVIEW OF LAKE AND DAM

PHASE I INSPECTION REPORT
NATIONAL DAM SAFETY PROGRAM
CITY LAKE DAM

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APPENDIX

SECTION 1 - PROJECT INFORMATION

1.1 GENERAL

a. Authority. The National Dam Inspection Act, Public Law 92-367, authorized the Secretary of the Army, through the Corps of Engineers, to initiate a program of safety inspection of dams throughout the United States. Pursuant to the above, the District Engineer of the St. Louis District, Corps of Engineers, directed that a safety inspection of the City Lake Dam be made. The 1975 Inventory of Dams for the State of Missouri called this dam Hanesville Dam, for the purpose of this report it will be referenced by its common name of City Lake Dam.

b. Purpose of Inspection. The purpose of the inspection was to make an assessment of the general condition of the dam with respect to safety, based upon available data and visual inspection, in order to determine if the dam poses hazards to human life or property.

c. Evaluation Criteria. Criteria used to evaluate the dam were furnished by the Department of the Army, Office of the Chief of Engineers, in "Recommended Guidelines for Safety Inspection of Dams". These guidelines were developed with the help of several Federal agencies and many State agencies, professional engineering organizations, and private engineers.

1.2 DESCRIPTION OF PROJECT

a. Description of Dam and Appurtenances.

(1) The dam is an earth structure located in the Valley of Town Creek in central Cass County, Missouri (Plate 1). The dam has a minimum height of 28 feet with a crest width of 11 feet. It is approximately 700 feet long with an upstream slope of 1.0 vertical on 1.6 horizontal and a broken downstream slope of 1.0 vertical on 2.2 horizontal above and 1.0 vertical on 2.0 horizontal below. Topography in the vicinity of the dam is shown on Plate 2.

(2) A concrete straight-drop or free overfall type spillway is located near the left abutment which empties into a trapezoidal concrete discharge channel which in turn discharges into Lake Luna approximately 200 feet downstream.

(3) The abutments at each end of the dam are lower than the dam itself. These low sections will act as emergency spillways in conditions of high inflows (see Plate 4).

(4) Pertinent physical data are given in paragraph 1.3.

b. Location. The dam is located in central Cass County, Missouri, as indicated on Plate 1. The lake formed by the dam is shown on the United States Geological Survey 7.5 minute series quadrangle map for Harrisonville, Missouri in Section 34 of T45N, R31W.

c. Size Classification. Criteria for determining the size classification of dams and impoundments are presented in the guidelines referenced in paragraph 1.1c above. Based on these criteria, the dam and impoundment are in the small size category.

d. Hazard Classification. The hazard classification assigned by the Corps of Engineers for this dam is as follows: The City Lake Dam has a high hazard potential, meaning that the dam is located where failure may cause loss of life, and serious damage to homes, agricultural, industrial and commercial facilities, and to important public utilities, main highways, or railroads. For the City Lake Dam the estimated flood damage zone extends downstream for approximately two miles. Within the damage zone are Lake Luna, 12 homes, two buildings, U.S. Highway 71, and the St. Louis/San Francisco and the Missouri Pacific railroads.

e. Ownership. The dam is owned by City of Harrisonville, P.O. Box 367, Harrisonville, Missouri 64701.

f. Purpose of Dam. The dam forms a 21-acre recreational lake.

g. Design and Construction History. Data relating to the design and construction were not available. Information on some post construction changes is available which is presented in paragraph 6.1(d).

h. Normal Operating Procedure. Normal rainfall, runoff, transpiration, and evaporation all combine to maintain a relatively stable water surface elevation.

1.3 PERTINENT DATA

a. Drainage Area - 461 acres

b. Discharge at Damsite.

(1) Normal discharge at the damsite is through an uncontrolled spillway.

(2) Estimated experienced maximum flood at damsite - Unknown.

(3) Estimated ungated spillway capacity at maximum pool elevation 2,530 cfs (top of Dam El.929.7).

c. Elevation (Feet Above M.S.L.).

(1) Top of dam - 929.7 ± (see Plate 5)

(2) Spillway crest - 926.0

(3) Streambed at toe of dam - 902.0 ±

(4) Maximum tailwater - Unknown.

d. Reservoir.

(1) Length of maximum pool - 2,700 feet ±

(2) Length of normal pool - 2,000 feet ±

e. Storage (Acre-feet).

(1) Top of dam - 206

(2) Spillway crest - 107 (from 1975 inventory)

(3) Design surcharge - Not available.

f. Reservoir Surface (Acres).

(1) Top of dam - 32

(2) Spillway crest - 21

g. Dam.

(1) Type - Earth embankment

(2) Length - 700 feet ±

(3) Height - 28 feet ±

(4) Top width - 11 feet

(5) Side slopes - upstream face 1.0 V on 1.6 H, downstream face 1.0 V on 2.2 H (see Plate 5)

(6) Zoning - Unknown.

(7) Impervious core - Unknown.

(8) Cutoff - An 8 foot wide clay-filled trench of unknown depth located below the downstream berm (from Black & Veatch 1947 drawing).

(9) Grout curtain - Unknown.

h. Diversion and Regulating Tunnel - None.

i. Spillway.

(1) Type - Concrete free overfall.

(2) Width of channel - 50 feet.

(3) Crest elevation - 926.0 feet m.s.l.

(4) Gates - None.

(5) Upstream channel - Not applicable.

(6) Downstream channel - Concrete trapezoidal.

j. Regulating Outlets - None operating.

SECTION 2 - ENGINEERING DATA

2.1 DESIGN

Design data were unavailable.

2.2 CONSTRUCTION

Construction records were unavailable.

2.3 OPERATION

The maximum recorded loading on the dam is unknown.

2.4 GEOLOGY

Bedrocks in the site area consist of limestones and shales of the Kansas City Group and shales and sandstones of the Pleasanton Group. The overburden soils generally consist of silty clays and clayey silts of residual and loessial origin. It is likely that along the Town Creek the surface deposits are of alluvial origin. No rock outcrops were observed in the site area. Soils in the watershed area consist of Grundy, Polo-Sogn, and Dennis-Roseland soils. Grundy soils were formed from loess and tend to lie on broad and gently sloping divides. The Polo-Sogn soil association lies downslope from Grundy soils and have limestone beneath them. Polo soils have over five feet of loess and shales or weathered limestone. Sogn soils have limestone at shallow depths and lie on steeper slopes than Polo or Grundy. The lower part of the watershed consist of Dennis-Roseland soils. Dennis soils lie on the more gently sloping areas whereas Roseland soils lie on short steep slopes where soft shales are at shallow depths. An outcrop of thin bedded micaceous sandstone was observed at the right abutement.

2.5 EVALUATION

a. Availability. No engineering data could be obtained. Only available data consist of a drawing by Black & Veatch dated 1947 which shows some improvements to be made to the existing dam. Only the first phase of the improvements as shown on this drawing was made. The first phase required flattening of the downstream slope and providing a downstream stabilizing berm. The second phase which would have required raising the dam by about 6 feet, was never completed.

b. Adequacy. No engineering data were available upon which to make a detailed assessment of the design, construction, and operation. Detailed seepage and stability analyses should be performed as required by the guidelines.

c. Validity. The validity of the design, construction, and operation could not be determined due to the lack of engineering data.

SECTION 3 - VISUAL INSPECTION

3.1 FINDINGS

a. General. A visual inspection of City Lake Dam was made on 12 April 1979. The inspection team included professional engineers with experience in dam design and construction, hydrology - hydraulic engineering, and geotechnical engineering. Specific observations are discussed below. No observations were made of the condition of the upstream face of the dam below the pool elevation at the time of the inspection.

b. Dam. The inspection team observed the following items at the dam. The upstream slope of the embankment above the water level is very steep due to erosion and sloughing. The riprap on the upstream face has apparently slid beneath the water level and exposed the embankment materials. On the downstream slope erosion has occurred near the spillway. The downstream face was apparently covered with a heavy growth of trees and brush; the stumps indicate that the downstream slope was recently cleared. The downstream slope lacks slope protection and will erode if a stand of grass is not established soon. Apparently the presence of brush and trees in the past prevented the grass growth. The downstream slope is rather steep just above the berm. The steeper slope possibly resulted from widening of a gravel road running along the berm. Some sloughing of the downstream slope was observed above the berm which appeared to be due to erosion from the drainage ditch along the berm. No significant seepage was observed from the dam except some minor wetness of the downstream slope. The embankment material appears to be silty clay. Several small rodent burrows were noted on the downstream face. No evidence of cracking or settlement was observed on the embankment.

c. Appurtenant Structures. The inspection team observed the following items pertaining to appurtenant structures. A concrete free overfall spillway which was constructed near the left abutment appears in good condition. The spillway is acting as a broad-crested weir. The spillway discharges into a concrete trapezoidal channel (rounded at corners) with an approximate length of 180 feet which in turn discharges into Lake Luna downstream. The embankment slopes on both sides of the spillway are protected with concrete. Some grouting at the spillway was performed in 1978, according to the City Engineer, possibly to reduce seepage. Several holes which were patched with cement grout were observed in the concrete blanket beside the spillway. A small amount of seepage (less than 1 gpm) was observed coming from one of these patched holes. Minor cracking and scaling of the spillway and the discharge channel concrete was observed. Low points in the natural material upstream from the dam at both left and right abutments would be overtopped by high lake stages prior to overtopping the dam embankment. Overflow of the right abutment would follow a gravel road around the end of the dam and worsen the erosion along the berm. Overflow of the left abutment would

run down a flat grassy slope to a paved park road. Overflow of the left abutment would not endanger the embankment.

d. Reservoir Area. No slides or excessive erosion due to wave action were observed along the shore of the reservoir. Topography of the contributing watershed is characterized by gently rolling hills of low relief. The vegetation in the watershed is primarily comprised of grassland and woods.

e. Downstream Channel. The downstream spillway channel is a concrete trapezoidal channel with rounded corners and appears to be in fair condition. The downstream channel empties into Luna Lake.

3.2 EVALUATION

The various minor deficiencies observed at the time of the inspection are not believed to represent any immediate safety hazard. They do, however, warrant repair and future monitoring and control.

(1) The absence of upstream riprap is a cause of the sloughing and erosion of the embankment material. The erosive wave action occurs at relatively infrequent intervals during heavy storms.

(2) The drainage ditch along the toe of the dam has caused erosion of the embankment material which has resulted in sloughing and sliding of the back slope of the dam. The lack of slope protection on the back slope will result in continued erosion of the embankment material.

(3) The cutting of the trees on the embankment slopes will allow the roots to decay and possibly develop a piping problem.

(4) Burrowing animals have been responsible for piping failures in a number of small earth dams in this country. The worst pests have been muskrats and ground squirrels.

SECTION 4 - OPERATIONAL PROCEDURES

4.1 PROCEDURES

The pool is primarily controlled by rainfall, runoff, evaporation, and capacity of the uncontrolled spillway.

4.2 MAINTENANCE OF DAM

The only known maintenance are recent clearing of brush and trees from the embankment slopes and spillway grouting.

4.3 MAINTENANCE OF OPERATING FACILITIES

No operating facilities are known to exist.

4.4 DESCRIPTION OF ANY WARNING SYSTEM IN EFFECT

The inspection team is not aware of any existing warning system for this dam.

4.5 EVALUATION

The stump and root system for the larger trees recently cut from the embankment should be removed under the supervision of an engineer experienced in dam design, construction, and maintenance before the roots begin to decay leaving voids which can cause piping. With removal of the brush, the embankment slopes have been left bare without protection from erosion.

SECTION 5 - HYDRAULIC/HYDROLOGIC

5.1 EVALUATION OF FEATURES

a. Design Data. Design data pertaining to hydrology and hydraulics were unavailable.

b. Experience Data. The drainage area and lake surface area are developed from USGS Harrisonville Quadrangle Map. The spillway and dam layouts are from surveys made during the inspection.

c. Visual Observations.

(1) The spillway and concrete discharge channel are in good condition. Minor cracking and scaling of the concrete was observed.

(2) No facilities are available which could serve to draw down the pool. A concrete intake structure is visible in the lake. The Black & Veatch 1947 drawing shows an 8-inch water line connected to this structure. This line was not observed during the inspection.

(3) A spillway and exit channel are located near the left abutment. Flows over the spillway and through the spillway channel do not endanger the embankment.

d. Overtopping Potential. The spillway will not pass the probable maximum flood without overtopping the dam. The probable maximum flood is defined as the flood discharge that may be expected from the most severe combination of critical meteorologic and hydrologic conditions that are reasonably possible in the region. The spillway and abutments will pass 40 percent of the probable maximum flood without overtopping the dam. This flood is greater than the 100-year flood calculated to be 1,990 cfs developed from a 24 hour, 100-year rainfall. According to the recommended guidelines from the Department of the Army, Office of the Chief of Engineers, a high hazard dam of small size should pass 50 to 100 percent of the probable maximum flood. Based on the downstream damage potential and the size of the watershed and the size of the lake, the appropriate spillway design would be 50 percent of the probable maximum flood. The portion of the estimated peak discharge of the probable maximum flood overtopping the dam would be 3,910 cfs of the total discharge from the reservoir of 6,440 cfs. The estimated duration of overtopping is 0.9 hours with a maximum height of 1.1 feet. The portion of the estimated peak discharge of 50 percent of the probable maximum flood overtopping the dam would be 570 cfs of the total discharge of the reservoir of 3,100 cfs. The estimated duration of overtopping is 0.3 hours with a maximum height of 0.2 feet. Failure of upstream water impoundments shown on the 1954 revised USGS map would not have a significant impact on the hydrologic or hydraulic analysis. Due to the lack

of slope protection and to the erodable nature of the embankment materials, overtopping for a sustained period of time could result in failure of the dam. Also overflow of the right abutment is likely to cause excessive erosion of the dam which could result in failure.

According to the St. Louis District, Corps of Engineers, the effect from rupture of the dam could extend approximately two miles downstream of the dam. There are 12 homes, two buildings, U.S. Highway 71, and the St. Louis/San Francisco and the Missouri Pacific railroads crossing downstream of the dam which could be severely damaged and lives could be lost should failure of the dam occur.

The failure of this dam may cause the Lake Luna Dam directly downstream to fail which would then cause the above mentioned damage.

SECTION 6 - STRUCTURAL STABILITY

6.1 EVALUATION OF STRUCTURAL STABILITY

a. Visual Observations. Visual observations of conditions which affect the structural stability of this dam are discussed in Section 3, paragraph 3.1b.

b. Design and Construction Data. No design data relating to the structural stability of the dam were found. Detailed seepage and stability analysis should be performed as required by the guidelines.

c. Operating Records. No operational records exist.

d. Post Construction Changes. The latest post construction changes were apparently made in the year 1947. The changes consisted of flattening the downstream slope from 1.0 V on 1.5 H to 1.0 V on 2.5 H and providing a downstream stabilizing berm and a clay-filled cutoff trench below the berm.

e. Seismic Stability. The dam is located in Seismic Zone 1 which is a zone of minor seismic risk. A properly designed and constructed earth dam using sound engineering principles and conservatism should pose no serious stability problems during earthquakes in this zone.

The seismic stability of an earth dam is dependent upon a number of factors: The important factors being embankment and foundation material classification and shear strengths; abutment materials, conditions, and strength; embankment zoning; and embankment geometry. Adequate descriptions of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment were not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the stability analysis required by the guidelines.

SECTION 7 - ASSESSMENT/REMEDIAL MEASURES

7.1 DAM ASSESSMENT

a. Safety. Several items noted during the visual inspection by the inspection team which should be corrected, monitored, or controlled are absence of upstream riprap, sloughing of the upstream embankment slope, erosion and sloughing of the downstream slope, small animal burrows in the embankment, tree stumps in the embankment, and lack of adequate slope protection on the downstream embankment slope.

b. Adequacy of Information. Due to the lack of engineering design data, the conclusions in this report were based only on performance history and visual conditions. The inspection team considers that these data are sufficient to support the conclusions herein. However, seepage and stability analyses are needed to satisfy the requirements of the guidelines.

c. Urgency. It is the opinion of the inspection team that a program should be developed as soon as possible to implement remedial measures recommended in paragraph 7.2b. If the safety deficiencies listed in paragraph 7.1a are not corrected, they will continue to deteriorate and lead to a serious potential of failure.

d. Necessity for Phase II. The Phase I investigation does not raise any serious questions relating to the safety of the dam or identify any serious dangers that would require a Phase II investigation.

e. Seismic Stability. This dam is located in Seismic Zone 1. Adequate description of embankment design parameters, foundation and abutment conditions, or static stability analyses to assess the seismic stability of this embankment was not available and therefore no inferences will be made regarding the seismic stability. An assessment of the seismic stability should be included as part of the recommended stability analysis.

7.2 REMEDIAL MEASURES

a. Alternatives. The present spillway and the abutments have the capacity to pass 40 percent of the probable maximum flood without overtopping the dam. In order to pass 50 percent of the probable maximum flood as required by the Guidelines, the spillway size and/or height of dam would need to be increased or the lake level could be lowered.

b. O&M Maintenance and Procedures. The following O&M maintenance and procedures should be implemented to correct the deficiencies observed at the time of inspection. If left unattended or unrepaired, each could ultimately become a potential source of failure.

(1) Check the downstream face of the dam periodically for seepage and stability problems. If seepage flows are observed or further sloughing on the downstream embankment slope is noted, the dam should immediately be inspected and the condition evaluated by an engineer experienced in design and construction of earthen dams.

(2) Riprap slope protection should be provided on the upstream slope. This protection is needed to prevent erosion of the embankment material due to wave action.

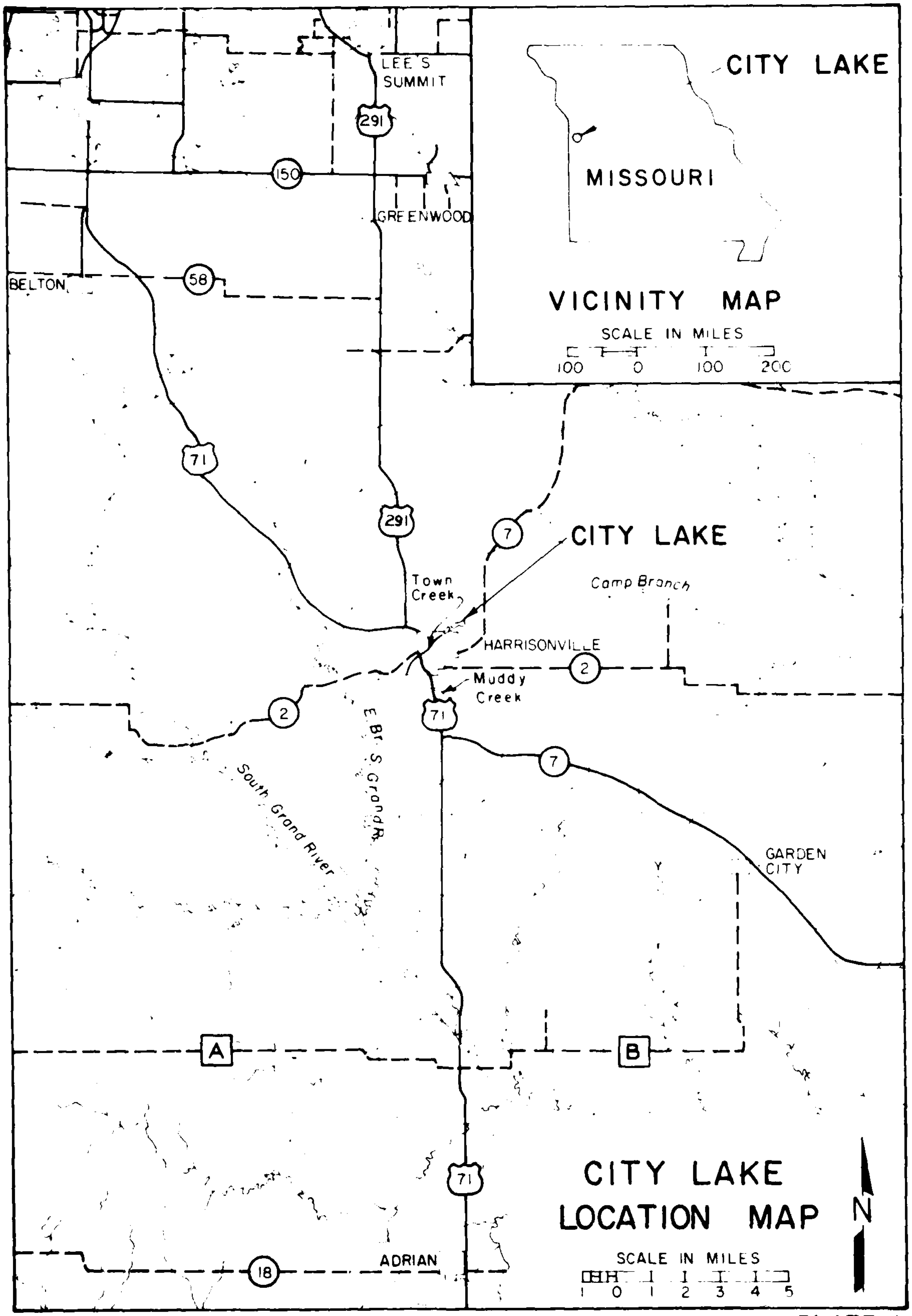
(3) Slope protection, such as good stand of grasses, should be developed on the back face of the embankment. The roadway and drainage ditch around the north end of the dam should be realined to allow for a flatter back slope on the dam where sloughing has occurred. The erosion and sloughing should be repaired.

(4) An engineer experienced in dam design and maintenance should be retained to supervise removal of stump and root system for the large trees recently cut from the embankment before the roots began to decay and cause a piping problem.

(5) The control and prevention of rodent activity should be considered. Animal burrows could lead to a piping failure. The holes should be filled and compacted to original specifications.

(6) Seepage and stability analysis should be performed by a professional engineer experienced in the design and construction of dams.

(7) A detailed inspection of the dam should be made periodically year by an engineer experienced in design and construction of dams. More frequent inspections may be required if additional deficiencies are observed or the severity of the reported deficiencies increases.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HARRISONVILLE
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PLATE 1

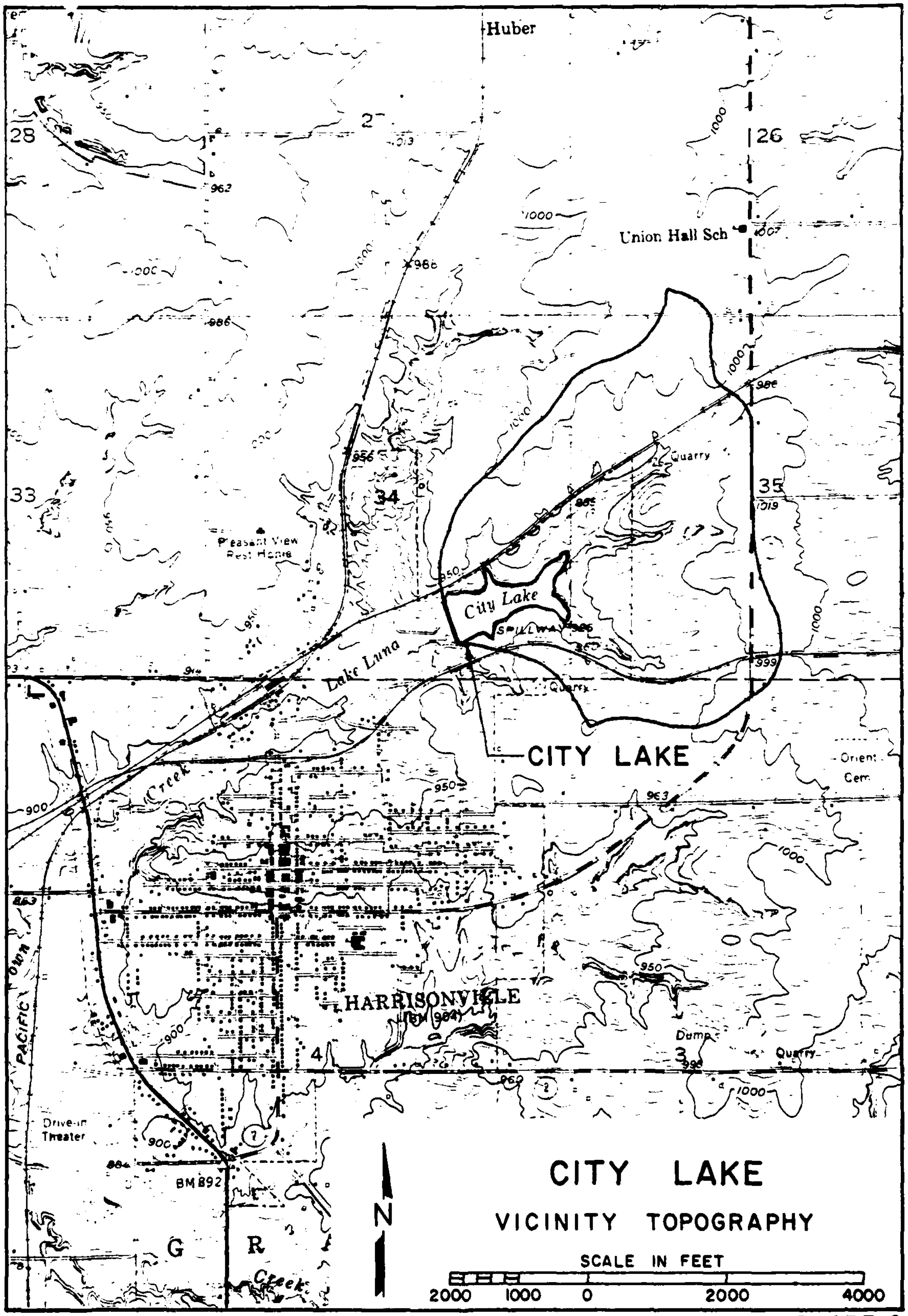

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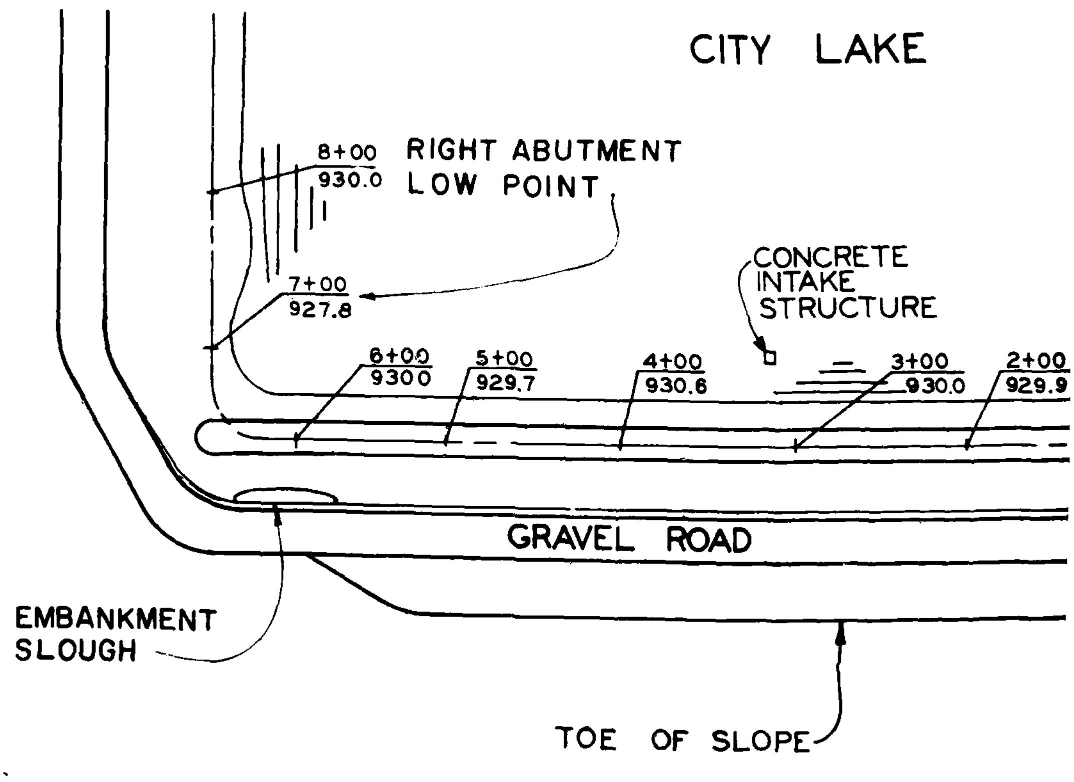
PLATE 2



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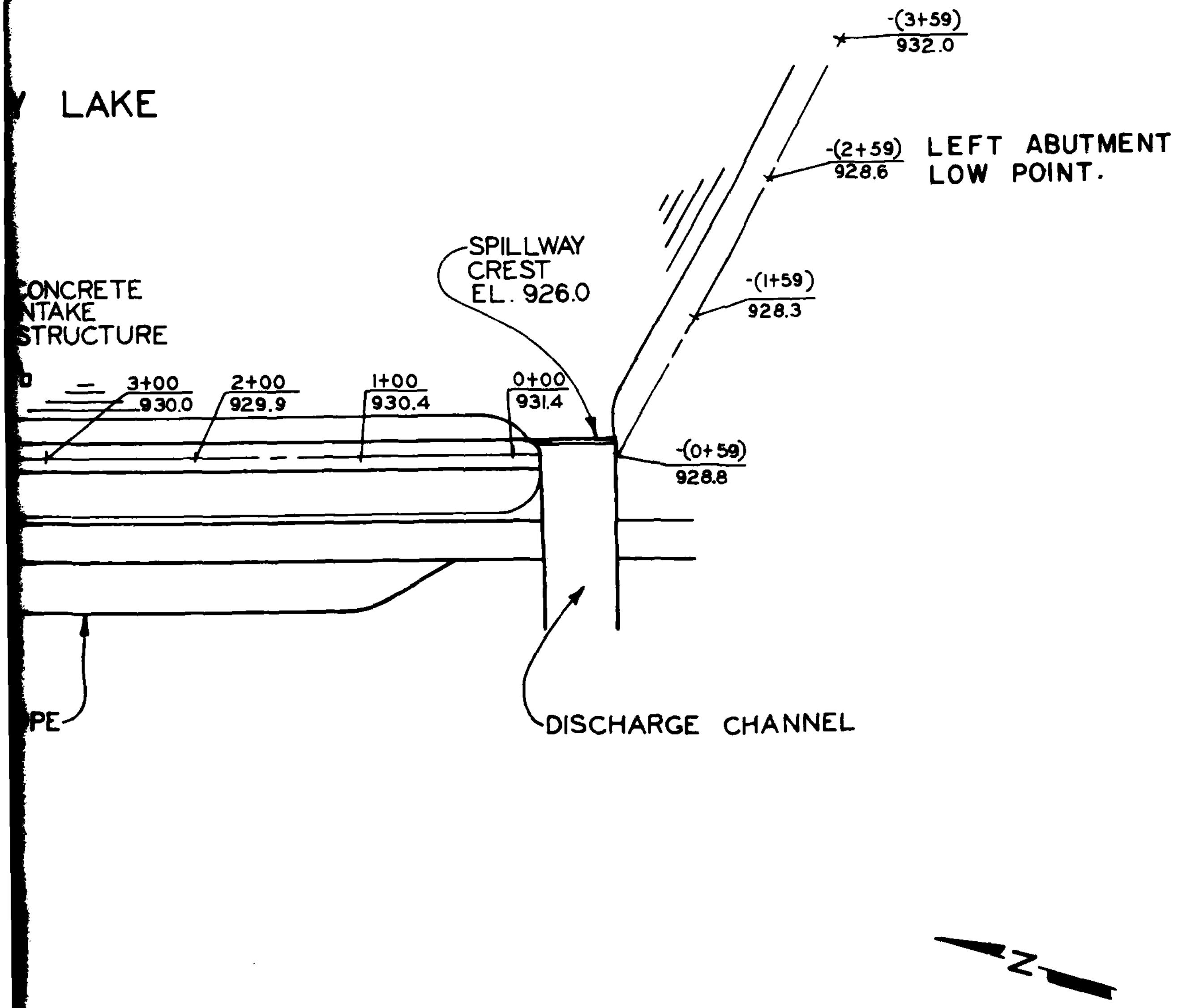
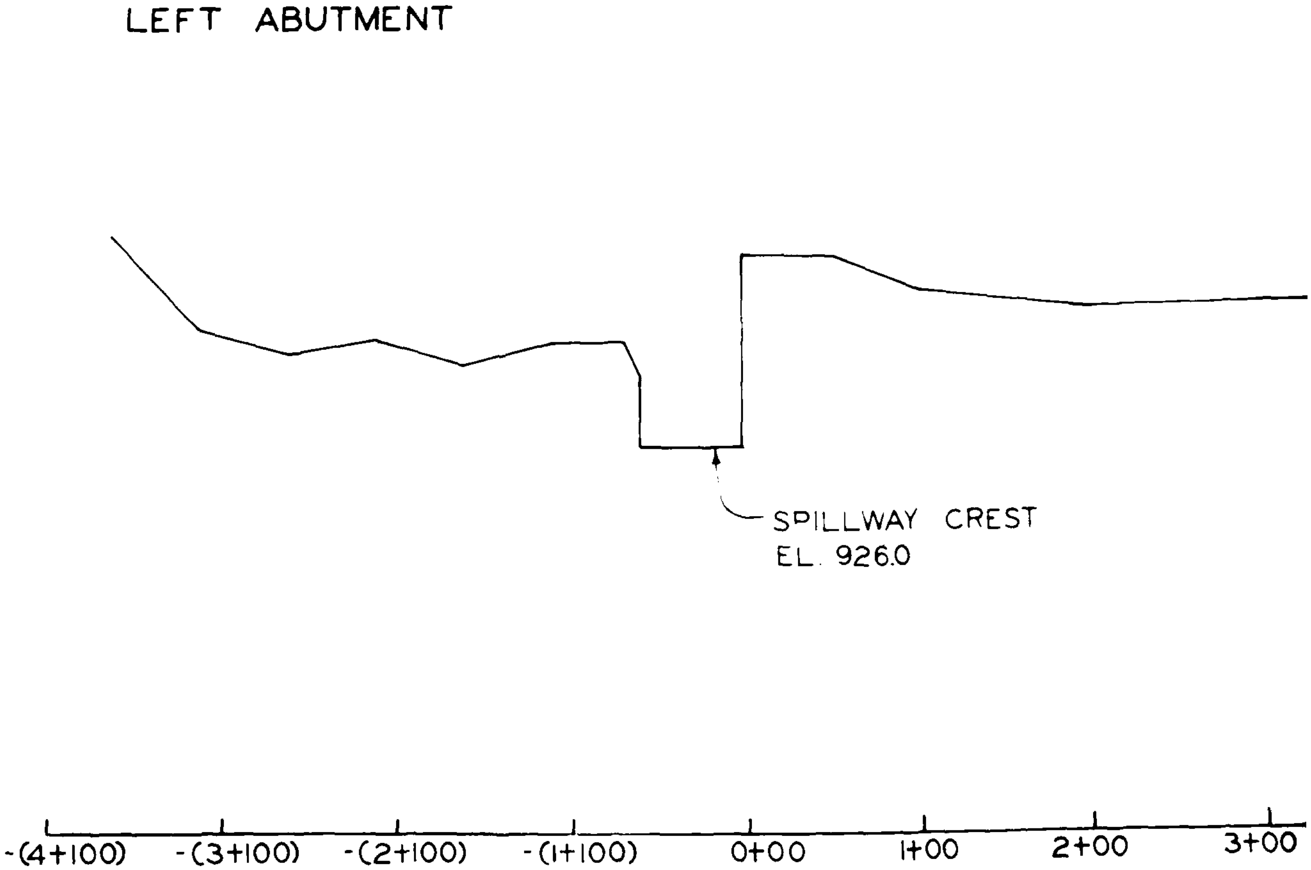
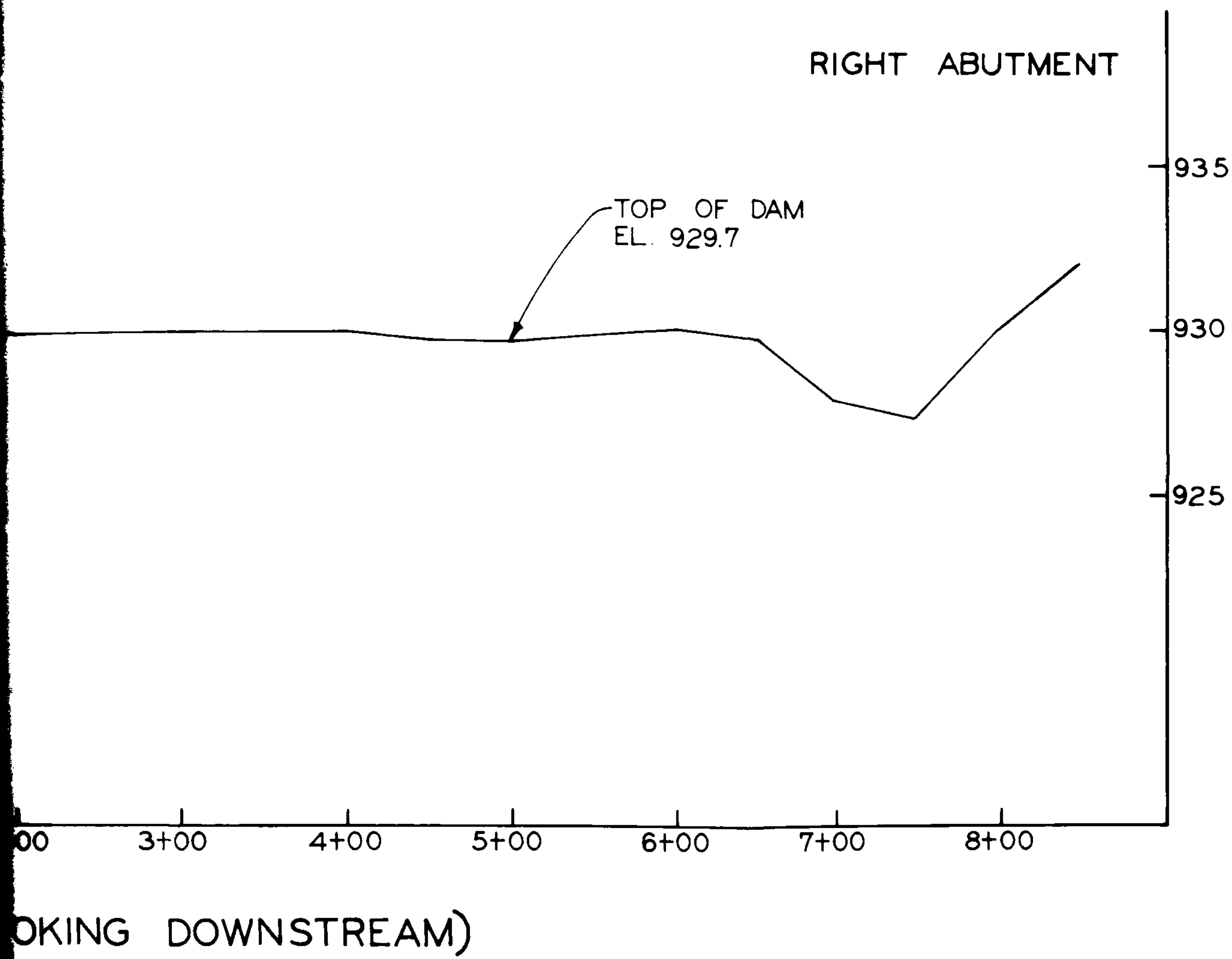
2+00
929.9
GRAVEL ROAD
EMBANKMENT
SLOUGH
TOE OF SLOPE



CITY LAKE
PLAN



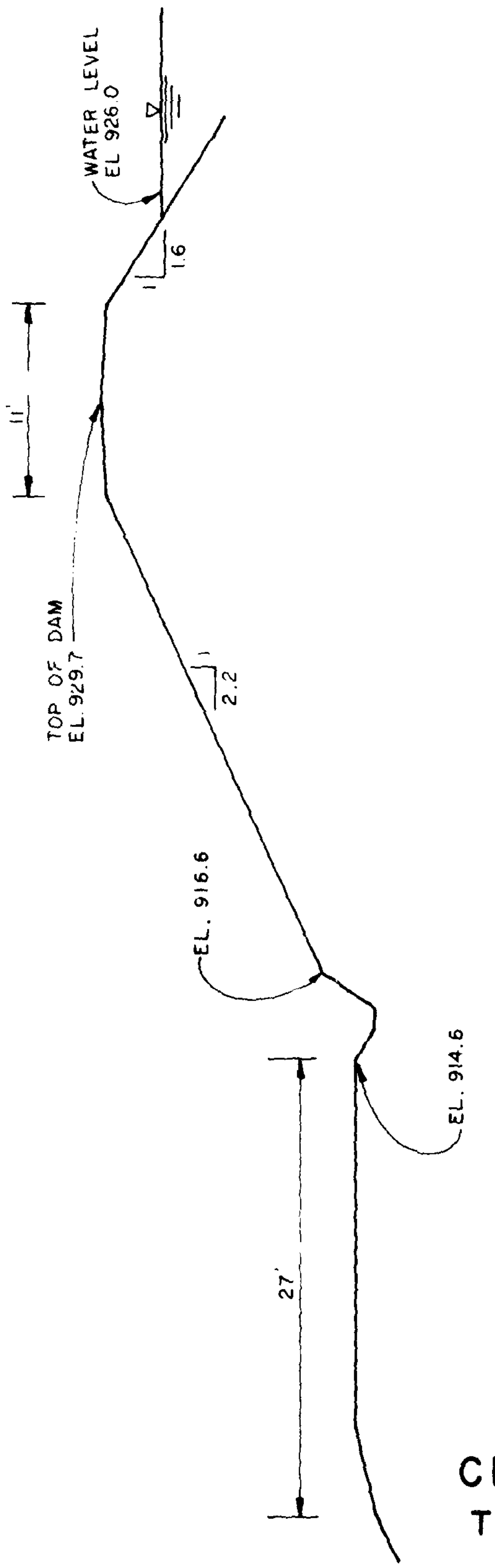
PROFILE (LOOKING DO



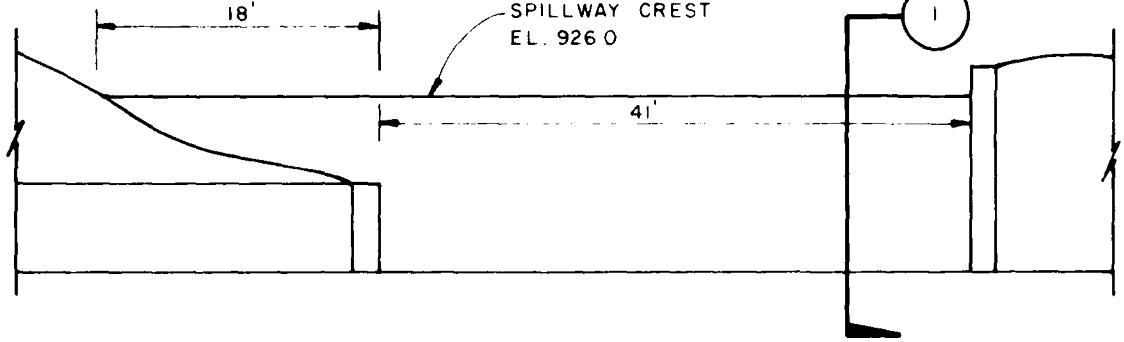
CITY LAKE
LONGITUDINAL
SECTION OF DAM

PLATE 4

12

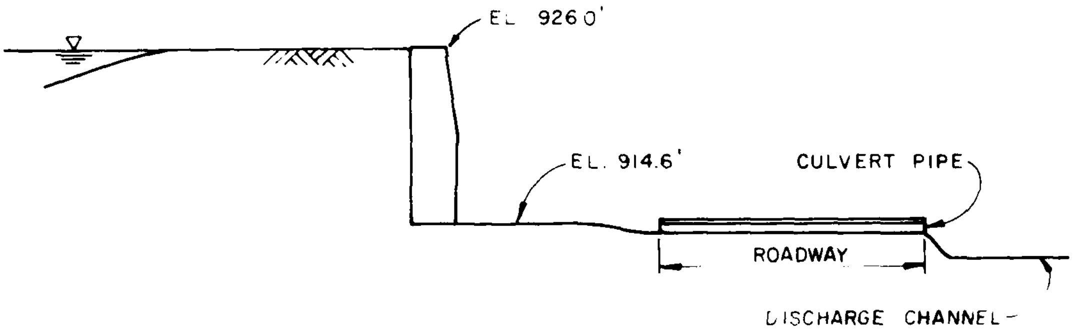


CITY LAKE DAM
TYPICAL SECTION



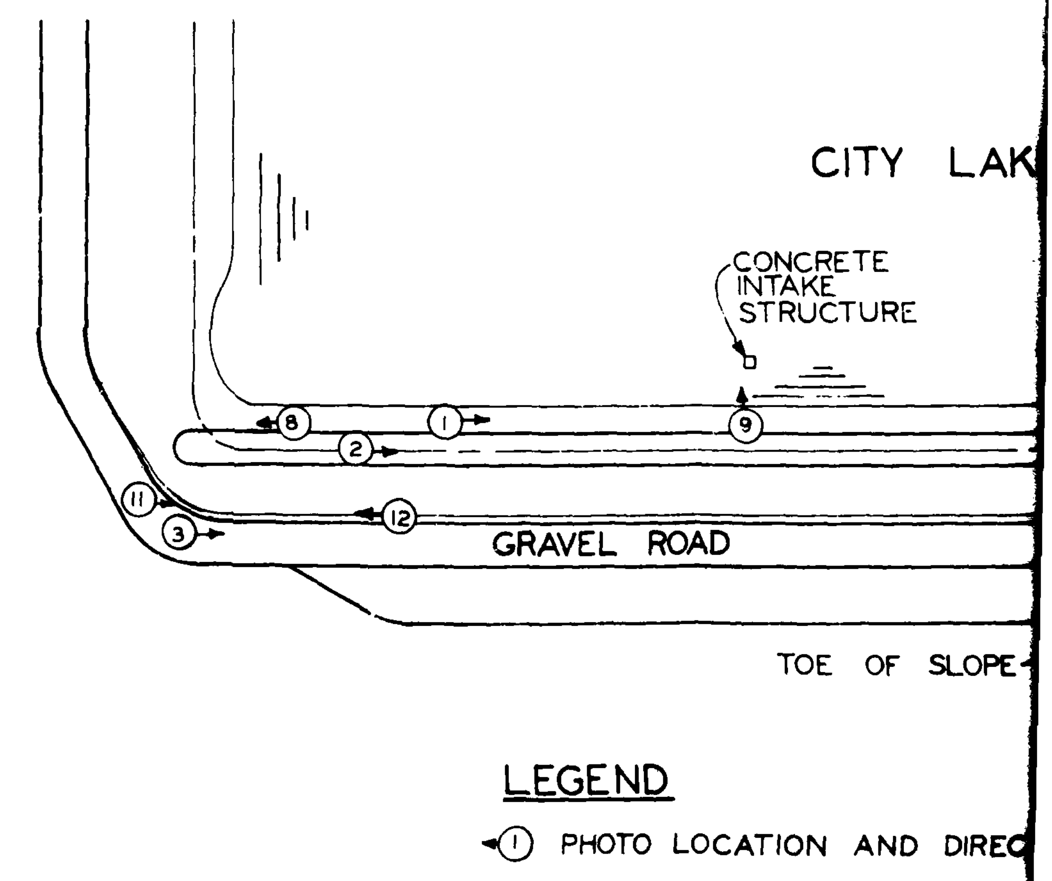
SPILLWAY ELEVATION

(LOOKING UPSTREAM)

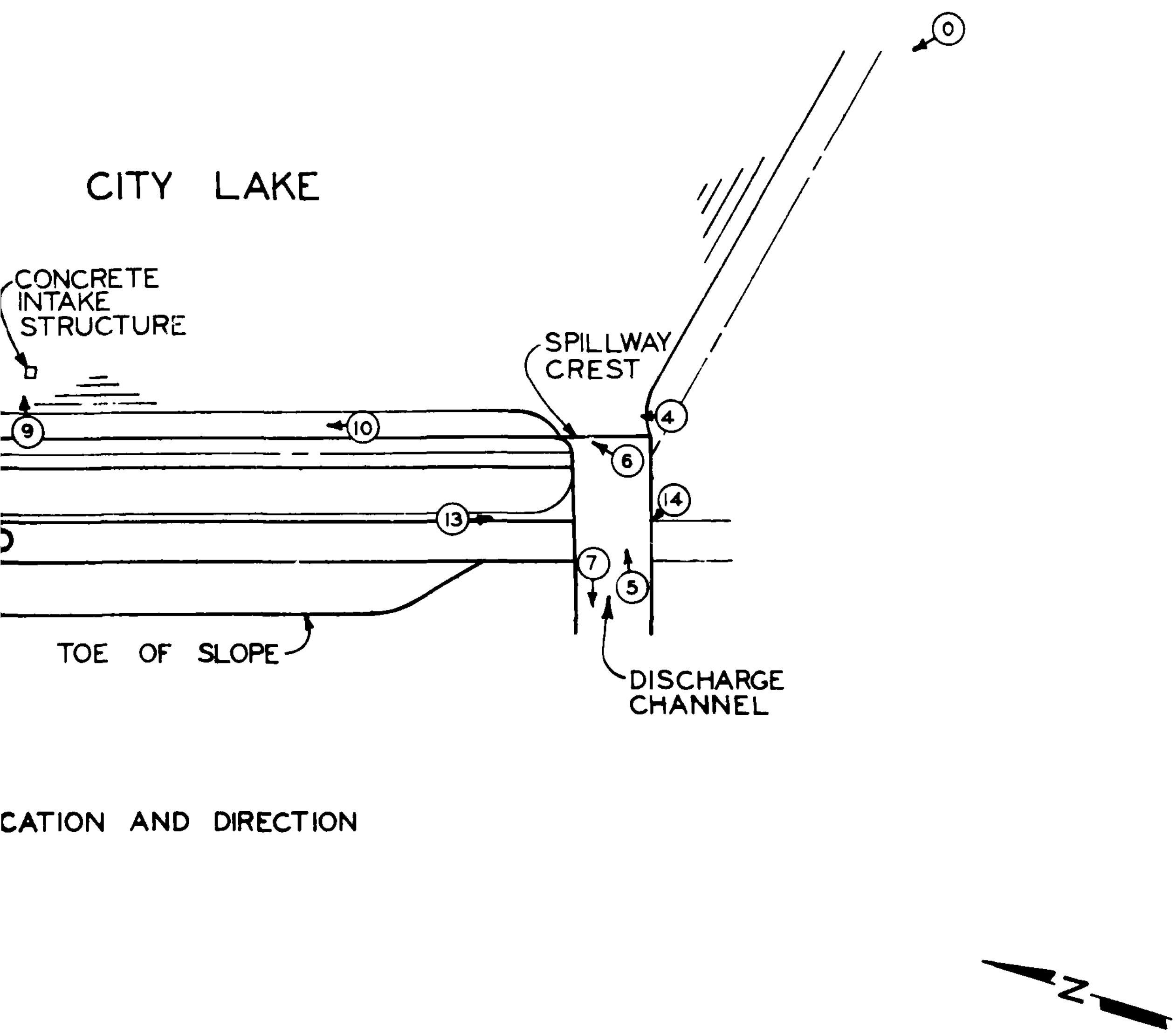


SPILLWAY - SECTION 1

CITY LAKE
SPILLWAY DETAILS



CITY LAK
CONCRETE INTAKE STRUCTURE
8
1
9
2
11
12
3
GRAVEL ROAD
TOE OF SLOPE
LEGEND
1 PHOTO LOCATION AND DIREC



CITY LAKE
PHOTO INDEX

PLATE 7

PHOTO 1: UPSTREAM FACE OF DAM LOOKING SOUTH

PHOTO 2: CREST OF DAM LOOKING SOUTH

PHOTO 3: BACK SLOPE OF DAM LOOKING SOUTH

PHOTO 4: SPILLWAY APPROACH

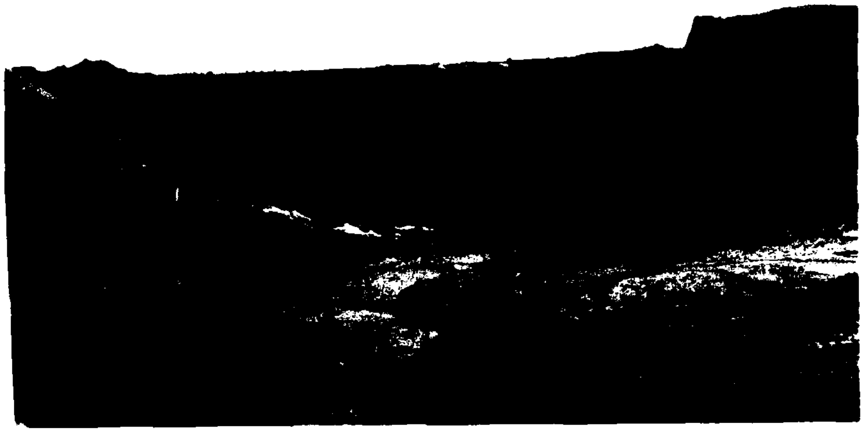


PHOTO 5: SPILLWAY

PHOTO 6: FACE OF SPILLWAY OVERFALL

PHOTO 7: CHANNEL BELOW SPILLWAY

PHOTO 8: LOW AREA AT RIGHT ABUTMENT

PHOTO 9: WATER SUPPLY INTAKE STRUCTURE

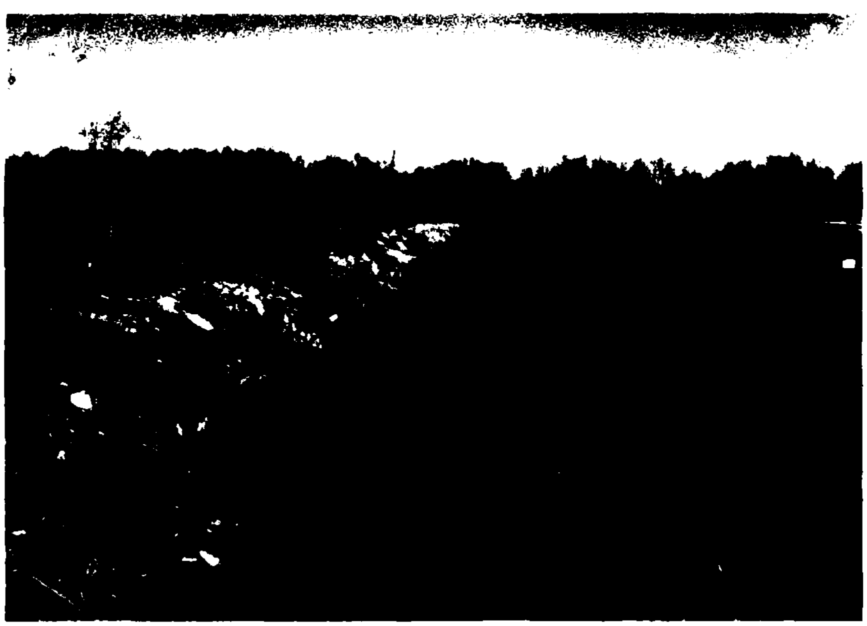


PHOTO 10: EROSION OF UPSTREAM FACE

PHOTO 11: DRAINAGE DITCH AT TOE OF SLOPE RIGHT END OF DAM

PHOTO 12: SLOUGHING OF EMBANKMENT AT DRAINAGE DITCH RIGHT END

PHOTO 13: EROSION OF DOWNSTREAM SLOPE AT LEFT END OF DAM

PHOTO 14: SEEPAGE FROM GROUT HOLE LEFT OF SPILLWAY

APPENDIX A

HYDROLOGIC COMPUTATIONS

HYDROLOGIC COMPUTATIONS

1. The Soil Conservation Service (SCS) dimensionless unit hydrograph (1) and HEC-1 (2) were used to develop the inflow hydrographs (see Plates A-1, A-2, and A-3), and hydrologic inputs are as follows:

a. Twenty-four hour, probable maximum precipitation determined from U.S. Weather Bureau Hydrometeorological Report No. 33.

200 square mile, 24 hour rainfall inches	- 25.0
10 square mile, 6 hour percent of 24 hour 200 square mile rainfall	- 101%
10 square mile, 12 hour percent of 24 hour 200 square mile rainfall	- 120%
10 square mile, 24 hour percent of 24 hour 200 square mile, rainfall	- 130%

b. Drainage area = 461 acres.

c. Time of concentration: $Tc = (11.9 \times L^3/H)^{0.385} = 0.37$ hours = 22 minutes (L = 0.87 miles = length of longest watercourse in miles, H = 104 feet = elevation difference in feet) (3)

d. The soil associations in this watershed are mainly Grundy, Polo-Sogn, and Dennis-Roseland (4).

e. Losses were determined in accordance with SCS methods for determining runoff using a curve number of 89 and antecedent moisture condition III. The hydrologic soil groups in the basin were B, C, and D (1).

f. The 100-year frequency inflow hydrograph was developed using a curve number of 76 and antecedent moisture condition II. The 100-year, 24 hour rainfall totaled 7.7 inches was provided by the Corps of Engineers, St. Louis District.

2. Spillway release rates are based on the broad-crested weir equation (3).

Broad-crested weir equation:

$Q = CLH^{1.5}$ (C = 3.0 L = 41 feet, H is the head on weir).

Discharge rates over the top of the dam are also based on the broad-crested weir equation:

$$Q = CLH^{1.5} \quad (C = 2.7,\ L = 18 \text{ to } 1{,}150 \text{ feet}).$$

3. The elevation-storage relationship above normal pool elevation was constructed by planimetering the area enclosed within each contour above normal pool. The storage between two elevations was computed by multiplying the average of the areas at the two elevations by the elevation difference. The summation of these increments below a given elevation is the storage below that level.

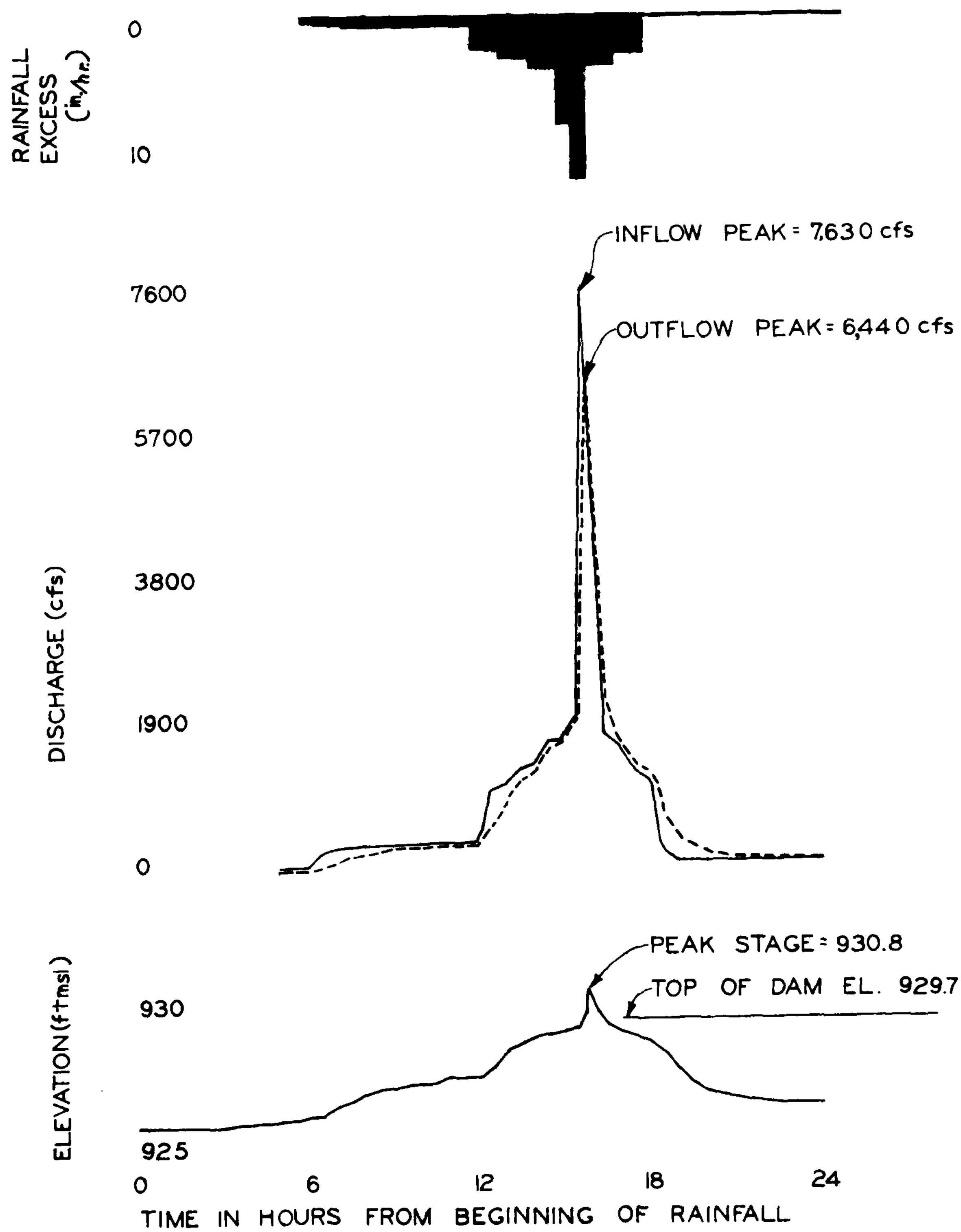
4. Floods are routed through the spillway using HEC-1, modified Puls to determine the capability of the spillway. Inflow and outflow hydrographs are shown on Plates A-1, A-2, and A-3.

(1) U.S. Department of Agriculture, Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, August 1972.

(2) U.S. Army Corps of Engineers, Hydrologic Engineering Center, Flood Hydrograph Package (HEC-1), Dam Safety Version, July 1978, Davis, California.

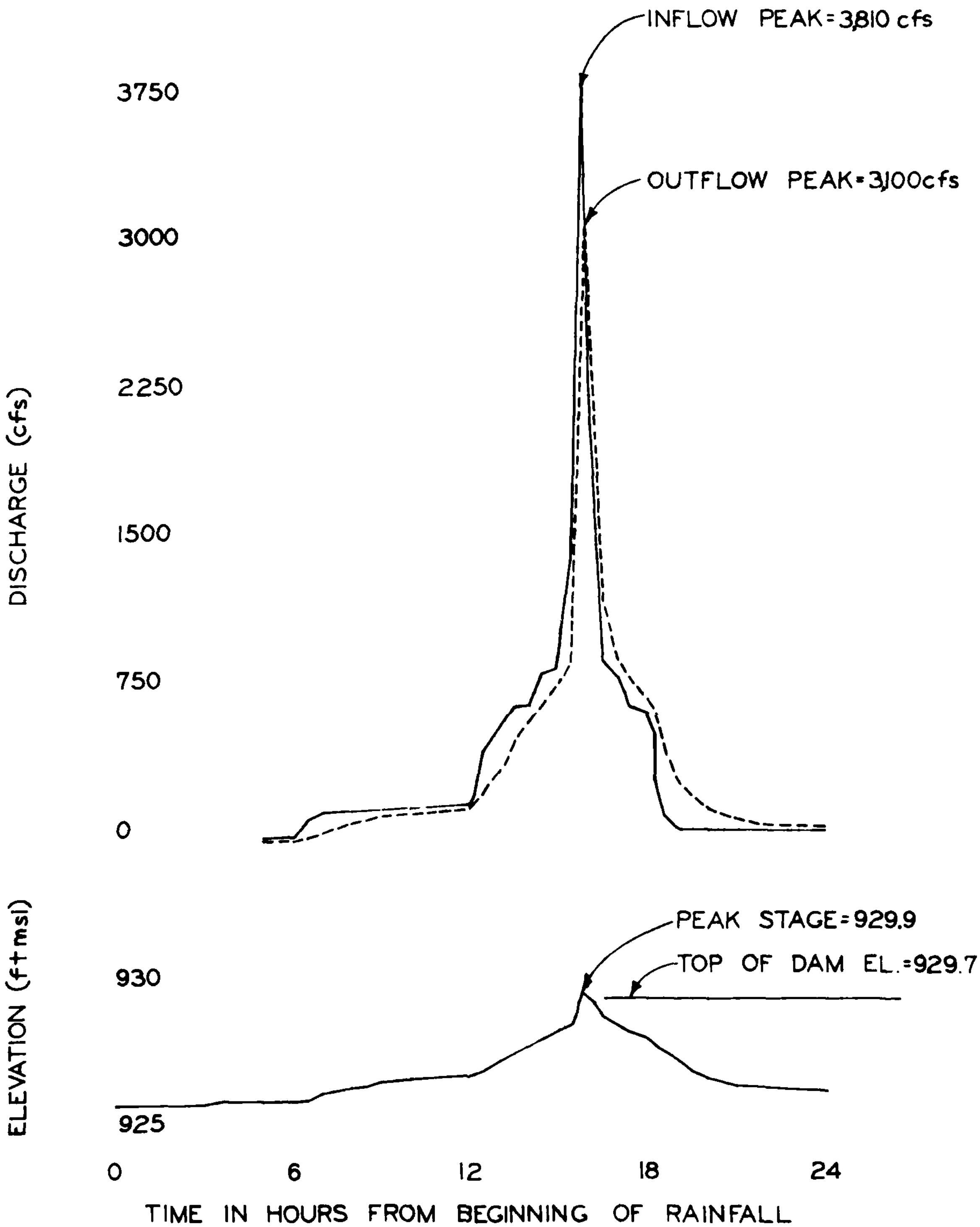
(3) U.S. Department of the Interior, Bureau of Reclamation, Design of Small Dams, 1974, Washington, D.C.

(4) Mid-America Regional Council, Regional Soils Guide, March 1976, Kansas City, Missouri.



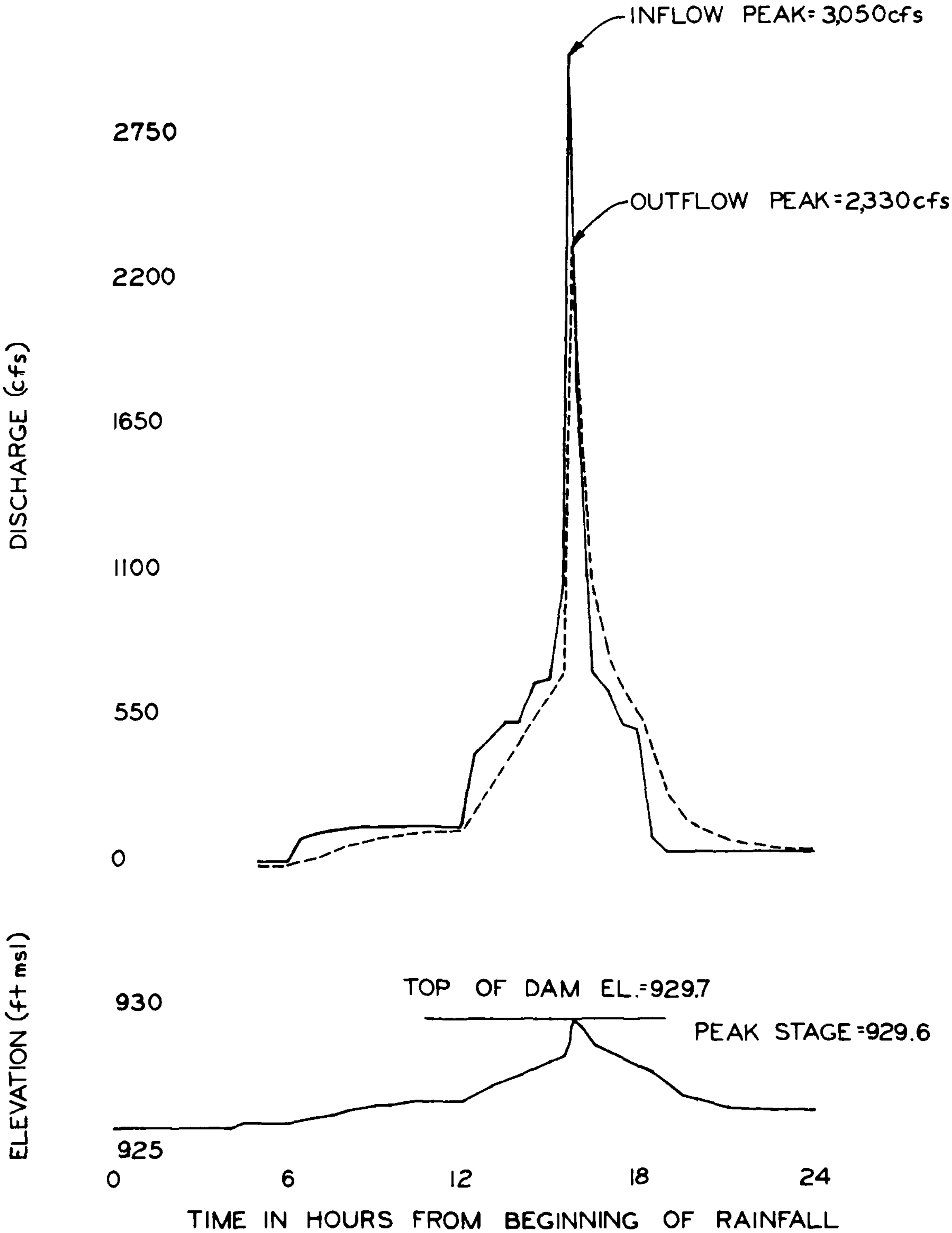
CITY LAKE DAM
PROBABLE MAXIMUM FLOOD
HYETOGRAPH, HYDROGRAPH AND STAGE-TIME CURVE

PLATE A-1



CITY LAKE DAM
50% PROBABLE MAXIMUM FLOOD
HYDROGRAPHS AND STAGE-TIME CURVE

PLATE A-2



CITY LAKE DAM
40% PROBABLE MAXIMUM FLOOD
HYDROGRAPHS AND
STAGE-TIME CURVES

PLATE A-3

```
******************************************
FLOOD HYDROG   H PACKAGE (HEC-1)
DAM SAFETY V. .ION      JULY 1978
 LAST MODIFICATION  25 SEP 78
******************************************
A1MISSOURI DAM INSPECTION PROGRAM
A2ST LOUIS DISTRICT  US ARMY CORPS OF ENGINEERS
A3 CITY LAKE I.D.#20314 & LAKE LUNA I.D.#20076
B    288       0       5       0       0       0       0       0       0       0
B1     5
J      1       9       1
J1   .10     .15     .20     .25     .30     .40     .45      .5      1.
K      0       1                               3       1
K1   CITY LAKE (24HR. PROBABLE MAXIMUM RUNOFF)
M      1       2    .720                       1
P           25.0     101     120     130
T                                                     -1     -89
W2           .22
X                      1
K      1       2                                       1
K1   ROUTING THROUGH CITY LAKE RESERVOIR
Y                              1       1
Y1     1                                              -1      -1
Y4926.0 926.1  926.2   926.3   926.4   926.5   927.0   927.6   928.0   928.6
Y4929.0 929.5  930.0   930.5   931.0   931.5   932.0
Y50.0   5.     15.     28.     43.     61.     172.    347.    520.    855.
Y51263. 2112.  3270.   5159.   7677.   10765.  14363.
$S0.    109.   607.
$E926.0 930.   940.
$$926.0
$D929.7
K      0       3                               3       1
K1   OTHER AREA ABOVE LAKE LUNA (24HR. PROBABLE MAXIMUM RUNOFF)
M      1       2   1.327                       1
P           25.0     101     120     130
T                                                     -1     -89
W2           .49
X                      1
K      2       4                                       1
K1   COMBINE HYDROGRAPHS - TOTAL INFLOW HYDROGRAPH TO LAKE LUNA (24HR. PMF)
K      1       5                                       1
K1   ROUTING THROUGH LAKE LUNA RESERVOIR
Y                              1       1
Y1     1                                              -1      -1
Y4901.5 901.7  902.0   902.5   903.2   903.9   904.5   905.0   905.5   906.0
Y4906.5 907.0  907.5   908.0   910.0
Y5    0.018.   71.     201.    446.    803.    1210.   1713.   2926.   4807.
Y57129. 9831.  12872.  16235.  32321.
$S0.0   247.
$E901.5 910.
$$901.5
$D904.7
K     99
```

PEAK FLOW AND STORAGE (END OF PERIOD) SUMMARY FOR MULTIPLE PLAN-RATIO ECONOMIC COMPUTATIONS
FLOWS IN CUBIC FEET PER SECOND (CUBIC METERS PER SECOND)
AREA IN SQUARE MILES (SQUARE KILOMETERS)

OPERATION	STATION	AREA	PLAN	RATIO 1 .10	RATIO 2 .15	RATIO 3 .20	RATIO 4 .25	RATIO 5 .30	RATIO 6 .40	RATIO 7 .45	RATIO 8 .50	RATIO 9 1.00
				RATIOS APPLIED TO FLOWS								
HYDROGRAPH AT	1	.72	1	763.	1144.	1525.	1906.	2288.	3050.	3431.	3813.	7625.
	(	1.86)	(	21.59)(	32.39)(	43.18)(	53.98)(	64.79)(	86.37)(	97.16)(	107.96)(	215.92)
ROUTED TO	2	.72	1	311.	531.	787.	1121.	1514.	2325.	2732.	3102.	6436.
	(	1.86)	(	8.82)(	15.05)(	22.28)(	31.73)(	42.88)(	65.83)(	77.36)(	87.84)(	182.26)
HYDROGRAPH AT	3	1.33	1	954.	1431.	1908.	2385.	2861.	3815.	4292.	4769.	9538.
	(	3.44)	(	27.01)(	40.51)(	54.02)(	67.52)(	81.03)(	108.04)(	121.54)(	135.04)(	270.09)
2 COMBINED	4	2.05	1	1264.	1962.	2694.	3505.	4376.	6034.	6852.	7650.	15446.
	(	5.30)	(	35.79)(	55.56)(	76.29)(	99.25)(	123.91)(	170.87)(	194.03)(	216.61)(	437.38)
ROUTED TO	5	2.05	1	887.	1521.	2418.	3308.	4150.	5861.	6659.	7453.	15307.
	(	5.30)	(	25.12)(	43.06)(	68.48)(	93.69)(	117.53)(	165.96)(	188.56)(	211.05)(	433.45)

SUMMARY OF DAM SAFETY ANALYSIS

PLAN 1 ....

	INITIAL VALUE	SPILLWAY CREST	TOP OF DAM
ELEVATION	926.00	926.00	929.70
STORAGE	0.	0.	101.
OUTFLOW	0.	0.	2579.

RATIO OF PMF	MAXIMUM RESERVOIR W.S.ELEV	MAXIMUM DEPTH OVER DAM	MAXIMUM STORAGE AC-FT	MAXIMUM OUTFLOW CFS	DURATION OVER TOP HOURS	TIME OF MAX OUTFLOW HOURS	TIME OF FAILURE HOURS
.10	927.48	0.00	40.	311.	0.00	16.17	0.00
.15	928.02	0.00	55.	531.	0.00	16.08	0.00
.20	928.48	0.00	68.	787.	0.00	16.08	0.00
.25	928.86	0.00	78.	1121.	0.00	16.00	0.00
.30	929.15	0.00	86.	1514.	0.00	16.00	0.00
.40	929.59	0.00	98.	2325.	0.00	15.92	0.00
.45	929.77	.07	103.	2732.	.08	15.92	0.00
.50	929.92	.22	107.	3102.	.25	15.92	0.00
1.00	930.75	1.05	147.	6436.	.92	15.92	0.00

DAT

FILM